

CHAPTER 5

BACKFILL FOR SUBSURFACE DRAINS

5-1. General. Placing backfill in trenches around drain pipes should serve a dual purpose: it must prevent the movement of particles of the soil being drained, and it must be pervious enough to allow free water to enter the pipe without clogging it with fine particles of soil. The material selected for backfill is called filter material.

5-2. Empirical design of filter materials. The criterion for filter and pipe perforations to keep protected soil particles from entering the filter or pipe in significant quantities is based on backfill particle sizes.

a. Filter stability criteria. The criteria for preventing movement of particles from the protected soil into or through the filter or filters are:

$$\frac{15 \text{ percent size of filter material}}{85 \text{ percent size of protected soil}} \leq 5$$

and

$$\frac{50 \text{ percent size of filter material}}{50 \text{ percent size of protected soil}} \leq 25$$

b. Exceptions to filter stability criteria. The above criteria will be used when protecting all soils except for nondispersive medium to highly plastic clays without sand or silt particles, which by the above criteria may require multiple-stage filters. For these clay soils, the D_{15} size of the filter may be as great as 0.4 millimeters, and the above D_{50} criteria will be disregarded. This relaxation in criteria for protecting medium to highly plastic clays will allow the use of a single-stage filter material; however, the filter must be well graded, and to offset the tendency of segregation of the filter material, a coefficient of uniformity not greater than 20 will be required. For dispersive clays, filter tests will be conducted to evaluate the effectiveness of the proposed filter material. Graded filters are labor intensive operations; therefore, the use of fabric filters (geotextiles) should be encouraged.

c. Filter permeability criteria. To permit free water to reach the pipe and maintain the condition of continuity, the filter material must be many times more pervious than the protected soil. It has been found that this condition is fulfilled when the following requirements are satisfied.

$$\frac{15 \text{ percent size of filter material}}{15 \text{ percent size of protected soil}} \leq 5$$

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d. Criteria for slots and holes. When pipes are embedded in filter drains, no unplugged ends should be allowed and the filter material in contact with pipes must be coarse enough not to enter the perforations or openings. To prevent clogging of the pipe with filter material, the following limiting requirements must be satisfied:

$$\text{for slots} \quad \frac{\text{85 percent size of filter material}}{\text{slot width}} > 1.2$$

$$\text{for circular holes} \quad \frac{\text{85 percent size of filter material}}{\text{hole diameter}} > 1.0$$

e. Criteria for porous concrete pipe and filter cloth. At present, established criteria for the design of granular filters adjacent to porous concrete pipes or for material being drained through filter cloths are not available. In the absence of such criteria, it is suggested that the following requirements be observed: For porous concrete pipe:

$$\frac{\text{15 percent size of aggregate in porous pipe}}{\text{85 percent size of filter adjacent to porous pipe}} \leq 5$$

For filter cloth (subject to limitations stated in para 6-9):

$$\frac{\text{85 percent size of material adjacent to cloth}}{\text{equivalent size of cloth openings}} \geq 1$$

A uniform, medium to fine sand (SP), graded such that at least 15 percent will pass the filter cloth, is washed over the cloth. A sieve analysis of the sand retained on the cloth is made. The 15 percent size of the retained material is used as the equivalent size of cloth openings. The test should be performed in the following manner. A piece of filter cloth is cut to fit in a No. 10 (or coarser) US Standard Sieve, and the perimeter of the cloth is sealed to the sieve wall with paraffin or other suitable sealant. Approximately 150 grams of sand is then placed on the filter cloth and washed with a water spray for a period of at least 20 minutes.

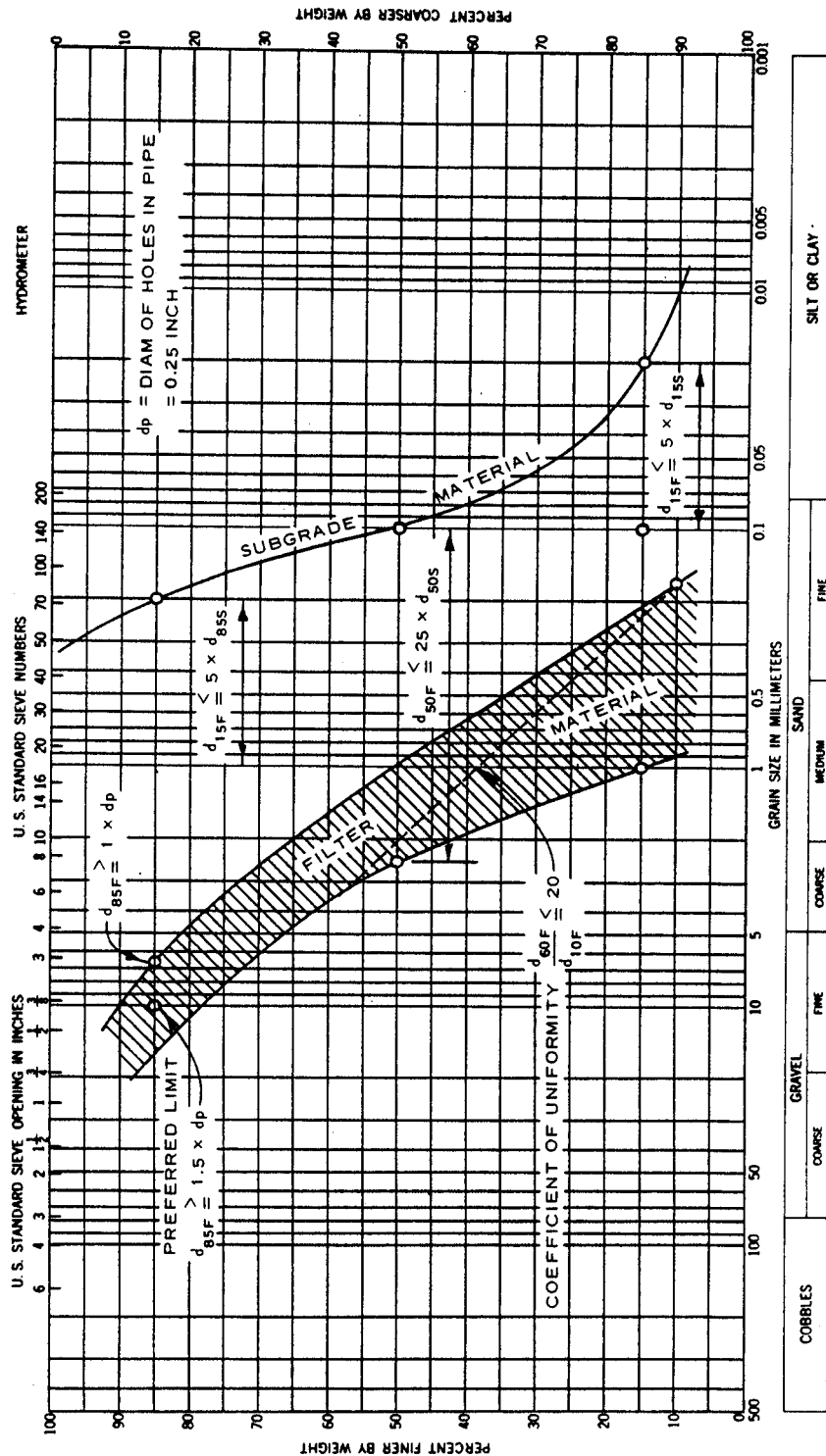
f. Limiting statement for filter cloths. The above tentative criteria for filter cloths are based on very limited laboratory tests. Adequate field performance data on filtering capabilities, ability to resist puncture or tearing when used adjacent to angular gravel, and resistance to deterioration by incrustation or chemical attack are not yet available for the different filter cloths on the market. Desirable procedures have not yet been established for specifications for and acceptable testing of filter cloths and factory- or field-made seams. Consequently, judgment is required in preparing specifications for the particular use of filter cloth contemplated.

g. Criteria for skip- and bell-and-spigot-type pipe. The criteria recommended for slots should be used for skip- and bell-and-spigot-type pipe. To preclude infiltration of filter material into the pipe, ratios somewhat greater than those above should be used wherever practicable to allow for variation in material and segregation during placement.

h. Granular filter materials. From the standpoint of simpler construction and lower costs, the selection of a filter material should be made from one layer wherever possible. If several layers of filter material are required, each layer must be designed in accordance with the criteria stated in this section. A typical example of design is shown in figure 5-1. The sand illustrated by the band contains sufficient amounts of fine gravel sizes to be safe from infiltration into pipes with small openings.

i. Filters in frost-susceptible areas. In determining a suitable filter material, the gradation of filters within the zone of frost penetration should be examined with respect to frost susceptibility. For the design of filters in frost-susceptible areas, consult EM 1110-3-138.

5-3. Construction of filter material. The major difficulties in construction of the filter are the problem with compaction in a restricted working space and the tendency toward segregation of particles. A material with a high coefficient of uniformity will tend to segregate during placement; therefore, a coefficient of uniformity greater than 20 is usually not desirable. For the same reason, filter materials should not be skip-graded. Segregation of coarse particles will result in the formation of voids through which fine particles may wash from the subgrade material. Segregation can best be prevented by placement of the material in a moist state. Moist placement of the sand may cause bulking of the sand particles. The use of water during installation of the filter material will collapse the structure of the bulked sand, therefore aiding in compaction and forming satisfactory transition zones between the various materials. The use of polyester fabric filter has proven successful as a filter material, but acceptance when frost susceptible soils are present is questionable. When polyester fabric filter is considered where frost susceptible soils exist, subgrades should be scarified and blended to reduce differential heave.



U.S. ARMY ENGINEER WATERWAYS EXPERIMENT STATION

FIGURE 5-1. DESIGN EXAMPLE FOR FILTER MATERIAL